

Neotropical Monogenoidea. 28. Ancyrocephalinae (Dactylogyridae) of Piranha and Their Relatives (Teleostei, Serrasalminidae) from Brazil and French Guiana: Species of *Notozothecium* Boeger and Kritsky, 1988, and *Mymarothecium* gen. n.

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ABSTRACT: Seven species (5 new) of *Notozothecium* and 4 new species of *Mymarothecium* are described and/or reported from the gills of 13 species of Serrasalminidae from the Brazilian Amazon and 1 serrasalmid from French Guiana: *N. bethae* sp. n. from *Myleus pacu* and *M. rhomboidalis*; *N. euzeti* sp. n. from *Acnodon normani*; *N. foliolium* sp. n. from *Pristobrycon* sp.; *N. minor* from *Pygocentrus nattereri*, *Serrasalmus elongatus*, *S. rhombeus*, *S. spilopleura*, and *Serrasalmus* sp. (2n = 58); *N. penetrarum* from *Pygocentrus nattereri*; *N. robustum* sp. n. from *Pristobrycon striolatus*; *N. teinodendrum* sp. n. from *Pristobrycon eigenmanni*, *Pristobrycon* sp., *Serrasalmus elongatus*, *S. gouldingi*, *S. manuellii*, *S. rhombeus*, and *Serrasalmus* sp. (2 of Jégu); *Mymarothecium dactylotum* sp. n. from *Pristobrycon* sp., *Serrasalmus rhombeus*, *Serrasalmus* sp. (2 of Jégu), and *Serrasalmus* sp. (2n = 58); *M. galeolum* sp. n. from *Pristobrycon eigenmanni*, *Pristobrycon* sp., *Pygocentrus nattereri*, *Serrasalmus gouldingi*, and *S. rhombeus*; *M. perplanum* sp. n. from *S. spilopleura*; and *M. whittingtoni* sp. n. from *Serrasalmus rhombeus*, *S. spilopleura*, and *Serrasalmus* sp. (2n = 58). The generic diagnosis of *Notozothecium* is emended, and *Mymarothecium* gen. n. is proposed for species with an expanded nonsclerotized vagina opening on the right side of the trunk, an anteromedial projection on the ventral bar, and a hooked termination of the articulation process of the accessory piece.

KEY WORDS: Monogenoidea, Dactylogyridae, Ancyrocephalinae, *Notozothecium*, *Mymarothecium* gen. n., *Mymarothecium dactylotum* sp. n., *Mymarothecium galeolum* sp. n., *Mymarothecium perplanum* sp. n., *Mymarothecium whittingtoni* sp. n., *Notozothecium bethae* sp. n., *Notozothecium euzeti* sp. n., *Notozothecium foliolium* sp. n., *Notozothecium minor*, *Notozothecium penetrarum*, *Notozothecium robustum* sp. n., *Notozothecium teinodendrum* sp. n., Serrasalminidae, *Acnodon normani*, *Myleus pacu*, *Myleus rhomboidalis*, *Pristobrycon eigenmanni*, *Pristobrycon striolatus*, *Pristobrycon* sp., *Pygocentrus nattereri*, *Serrasalmus elongatus*, *Serrasalmus gouldingi*, *Serrasalmus manuellii*, *Serrasalmus rhombeus*, *Serrasalmus spilopleura*, *Serrasalmus* sp., Amazon Basin, Brazil, French Guiana.

Serrasalminids are primary freshwater fishes of the Neotropical Region and are hosts to 52 described species of Dactylogyridae: 35 species of *Anacanthorus* Mizelle and Price, 1965 (*Anacanthorinae*), 1 of *Linguadactyloides* Thatcher and Kritsky, 1983 (*Linguadactyloidea*), and 6 of *Amphithecium* Boeger and Kritsky, 1988, 3 of *Cleidodiscus* Mueller, 1934, 2 of *Notozothecium* Boeger and Kritsky, 1988, 2 of *Notozothecium* Boeger and Kritsky, 1988, 1 of *Rhinoxenus* Kritsky, Boeger, and Thatcher, 1988, and 2 of *Uroleidus* Mueller, 1934 (all Ancyrocephalinae) (Mizelle and Price, 1965; Kritsky et al., 1979, 1988, 1992; Thatcher and Kritsky, 1983; Boeger and Kritsky, 1988; Van Every and Kritsky, 1992, 1995; Boeger et al., 1995). Since 1984, 20 ser-

rasalminid species were examined for Monogenoidea to further determine the diversity of dactylogyrids (Ancyrocephalinae) infesting this host group. Host species examined from the Amazon Basin during the present study include *Acnodon normani* Gosline, *Catopirion mento* (Cuvier), *Myleus pacu* (Schomburgk), *M. rubripinnis* (Müller and Troschel), *M. schomburgkii* (Jardine), *M. torquatus* (Kner), *Pristobrycon eigenmanni* (Norman), *Pristobrycon* sp., *P. striolatus* (Steindachner), *Pygocentrus nattereri* (Kner), *Pygopristis denticulata* (Cuvier), *Serrasalmus compressus* Jégu, Leão and dos Santos, *S. elongatus* Kner, *S. gouldingi* Fink and Machado-Allison, *S. manuellii* Fernández-Yépez, *S. rhombeus* (Linnaeus), *S. spilopleura* Kner, *Serrasalmus* sp. (2n

= 58), and *Serrasalmus* sp. (2 of Jégu). *Myelus rhomboidalis* (Cuvier) was obtained from a coastal river in French Guiana.

The present paper is the first of 4 contributions dealing with the Ancyrocephalinae from the gills of these 20 hosts and includes reports and/or descriptions of 7 species of *Notozothecium* Boeger and Kritsky, 1988, and 4 species of *Mymarothecium* gen. n. In the following 3 contributions, an additional 37 species of Ancyrocephalinae are recorded from these hosts, and the previously described species of *Cleidodiscus* and *Urocleidus* from serrasalmids are reassigned to new Neotropical genera (see Kritsky et al., in press a, b, c).

Materials and Methods

Serrasalmids were collected by hook-and-line or seine, gill, or throw net. Methods of parasite collection, preparation of helminths for study, measurement, and illustration are those of Kritsky et al. (1986). Measurements, in micrometers, represent straight-line distances between extreme points (except for the length of the copulatory organ of *Notozothecium* spp.) and are expressed as a mean followed by the range and number of specimens measured in parentheses; body length includes that of the haptor. The length of the copulatory organ of *Notozothecium* spp. is an approximation of total length obtained by using a Minerva curvimeter on camera lucida drawings; length of the accessory piece is that of the distal rod. Measurements of internal organs (gonads and pharynx), the body, and haptor bars were obtained from stained, unflattened specimens; those of the anchors, hooks, and copulatory complex were from unstained specimens mounted in Gray and Wess' medium. Numbering (distribution) of hook pairs follows that recommended by Mizelle (1936; see Mizelle and Price, 1963). Type and voucher specimens are deposited in the helminth collections of the Instituto Nacional de Pesquisas da Amazônia, Manaus, Brazil (INPA); the U.S. National Museum, Beltsville, Maryland (USNPC); and the University of Nebraska State Museum (HWML), as indicated in the respective descriptions or accounts. For comparative purposes, the following specimens were also examined: 4 paratypes (HWML 23666), 4 vouchers, (HWML 23665), 2 vouchers (USNPC 79809, 79810) of *Notozothecium penetrarum* Boeger and Kritsky, 1988; and 5 vouchers (personal collection of E. Belmont-Jégu, Manaus, Brazil) of *Notozothecium* sp. (= *N. bethae* sp. n.).

Presumed undescribed hosts have been provisionally identified by M. J. as *Pristobrycon* sp., *Serrasalmus* sp. (2 of Jégu), and *Serrasalmus* sp. (2n = 58). Hosts from the Rio Uatuma that were previously reported as *Pristobrycon* sp. by Kritsky et al. (1992) and Van Every and Kritsky (1992) have been subsequently identified as *S. gouldingi* by M. Jégu (unpubl.). Representative specimens of provisionally identified host taxa are deposited in the ichthyology collection of the INPA.

Taxonomic Account

Class Monogeneoidea Bychowsky, 1937

Order Dactylogyridea Bychowsky, 1937

Dactylogyridae Bychowsky, 1933

Ancyrocephalinae Bychowsky, 1937

Notozothecium Boeger and Kritsky, 1988

EMENDED DIAGNOSIS: Body comprising cephalic region, trunk, peduncle, haptor. Tegument thin, smooth or with scaled annulations. Two terminal, 2 bilateral cephalic lobes; head organs, unicellular cephalic glands present. Eyes 4; granules ovate. Mouth subterminal, midventral; pharynx muscular, glandular; esophagus short; 2 intestinal ceca confluent posterior to testis, lacking diverticula. Gonads intercecal, overlapping; testis dorsal to germarium. Vas deferens looping left intestinal cecum; seminal vesicle a sigmoid dilation of vas deferens. Two prostatic reservoirs; prostates comprising bilateral glandular areas lying dorsal to anterior portions of ceca. Genital pore midventral near level of cecal bifurcation. Copulatory complex comprising articulated copulatory organ, accessory piece; copulatory organ an elongate coiled tube with counterclockwise ring(s) (Kritsky et al., 1985); accessory piece with proximal articulation process, distal rod, terminal flabellate plate. Vagina single, nondilated, lightly sclerotized, looping right intestinal cecum, opening on dextrodorsal surface of trunk; seminal receptacle lying on midline anterior to germarium. Haptor globose to subhexagonal; with dorsal, ventral anchor/bar complexes, 7 pairs of hooks with ancyrocephaline distribution. Ventral bar with anteromedial projection. Hooks similar; each with truncate protruding thumb, delicate point, shank comprising 2 subunits; proximal subunit usually variable in length between hook pairs; FH loop extending to union of shank subunits. Parasites of gills of Serrasalmidae.

TYPE SPECIES: *Notozothecium penetrarum* Boeger and Kritsky, 1988, from *Pygocentrus nattereri*.

OTHER SPECIES: *Notozothecium bethae* sp. n. from *Mylesinus paraschomburgkii*, *M. paucisquamatus*, *Myelus pacu* (type host), and *M. rhomboidalis*; *N. euzeti* sp. n. from *Acnodon normani*; *N. foliolium* sp. n. from *Pristobrycon* sp.; *N. minor* Boeger and Kritsky, 1988, from *Pygocentrus nattereri* (type host), *S. elongatus*, *S. rhombeus*, *S. spilopleura*, and *Serrasalmus* sp.

(2n = 58); *N. robustum* sp. n. from *Pristobrycon striolatus*; and *N. teinodendrum* sp. n. from *P. eigenmanni* (type host), *Pristobrycon* sp., *S. elongatus*, *S. gouldingi*, *S. manuelli*, *S. rhombeus*, and *Serrasalmus* sp. (2 of Jégu).

REMARKS: Characters distinguishing this genus include the combined presence of a single sclerotized nondilated vagina looping the right intestinal cecum and opening on the dextrodorsal body surface, a ventral bar with an anteromedial projection, and a copulatory complex comprising a counterclockwise coiled copulatory organ and an accessory piece with proximal articulation process, distal rod, and terminal flabellate plate. Boeger and Kritsky (1988) reported that *Notozothecium penetrarum* had a single prostatic reservoir. Reexamination of the paratypes and present specimens of *N. penetrarum* confirms the presence of a second, poorly staining reservoir lying dextral to the previously described pyriform reservoir. All known species of *Notozothecium* have 2 prostatic reservoirs.

***Notozothecium penetrarum* Boeger and Kritsky, 1988
(Figs. 4–10)**

RECORDS: *Pygocentrus nattereri*: Furo do Catalão, Manaus, Amazonas (27 November 1984); Rio Guaporé, Surpresa, Rondônia (16 June 1984).

PREVIOUS RECORDS: *Pygocentrus nattereri* (type host): Furo do Catalão, Manaus, Amazonas; Ilha da Marchantaria, Rio Solimões, Manaus, Amazonas; Rio Mamoré, Surpresa, Rondônia; Rio Guaporé, Surpresa, Rondônia (type locality) (all Boeger and Kritsky, 1988).

SPECIMENS STUDIED: Four paratypes, HWML 23666; 15 vouchers, HWML 23665, USNPC 79809, 79810, 85727, 85728.

MEASUREMENTS (9 specimens collected during present study, USNPC 85727, 85728): Ventral anchor 35 (32–43; $n = 8$) long, base 32 (30–35; $n = 8$) wide; dorsal anchor 30 (28–36; $n = 8$) long, base 25 (21–30; $n = 4$) wide; hook prs. 1, 5–17 (15–18; $n = 7$), prs. 2, 6, 7–19 (18–20; $n = 13$), prs. 3, 4–20 (19–21; $n = 13$) long; copulatory organ 236 (210–245; $n = 9$) long, ring diameter 63 (56–69; $n = 7$); distal rod of accessory piece 62 (60–67; $n = 8$) long.

REMARKS: *Notozothecium penetrarum* is the largest species in the genus, with Boeger and Kritsky (1988) reporting specimens exceeding 1 mm in length. All specimens collected during the

present study were mounted unstained in Gray and Wess' medium; measurements of internal organs, body dimensions, and haptoral bars were not obtained.

Pygocentrus nattereri is widespread in the white waters of the western Amazon including the major tributaries of the Madeira and Japurá basins. The host is apparently absent (or rare) in black waters of the Amazon (Goulding, 1980), except that it occurs in reduced numbers in regions where a mixing of black and white water results during annual high-water periods such as in Lago Tapaná on the Rio Uatumã and Furo do Catalão near Manaus. In the eastern Amazon, this host is restricted to the white waters of the main Amazon River and its varzea foodplain and in the lower reaches of major Amazonian tributaries. Depending on hydrochemical characteristics, *P. nattereri* may extend from 20 to 80 km upstream in eastern tributaries.

Notozothecium penetrarum appears to be restricted to this host, and its known geographic distribution coincides with that of its host in the western Amazon. Geographic records for this parasite reported by Boeger and Kritsky (1988) and those recorded herein include the Madeira Basin and the main Amazon in the environs of Manaus. The parasite has been collected from the mixed waters of the Furo do Catalão near Manaus but not from the lower reaches of the Rio Uatumã (Lago Tapaná). *Pygocentrus nattereri* has not been examined for Monogenoidea from the eastern Amazon and its tributaries east of the Rio Uatumã.

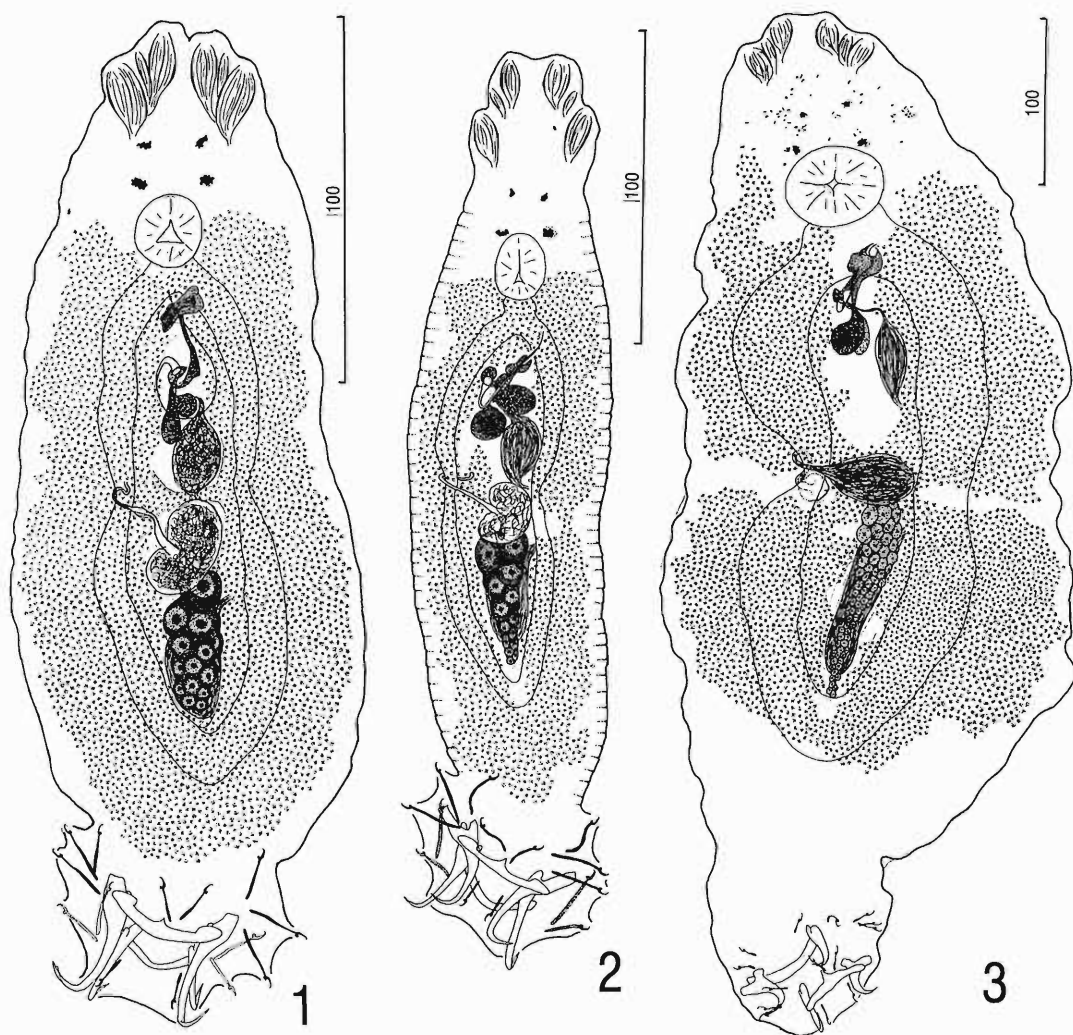
***Notozothecium bethae* sp. n.
(Figs. 1, 11–19)**

SYNONYM: *Notozothecium* sp. (of Belmont-Jégu, 1992).

TYPE HOST AND LOCALITY: *Myleus pacu*: Rio Pitinga, Cachoeira 40 Ilhas, Amazonas (12 October 1989).

OTHER RECORDS: *Myleus rhomboidalis*: Rio Approuague, Saut Mapaou, French Guiana (29 November 1989).

PREVIOUS RECORDS: *Mylesinus paraschomburgkii* Jégu, Santos, and Ferreira: Bacia do Rio Uatumã, Rio Capucapú, Cachoeira das Garças, Amazonas; Rio Pitinga, Cachoeira 40 Ilhas, Amazonas; Rio Trombetas, Cachoeira Porteira, Amazonas; Rio Jari, Cachoeira de Santo Antônio, Pará. *Mylesinus paucisquamatus* Jégu and



Figures 1–3. Whole-mount illustrations of *Notozothecium* species (composite, ventral views). 1. *Notozothecium bethae* sp. n. (from *Myelus pacu*). 2. *Notozothecium euzeti* sp. n. 3. *Notozothecium foliolum* sp. n. Each figure is drawn to respective 100- μ m scales.

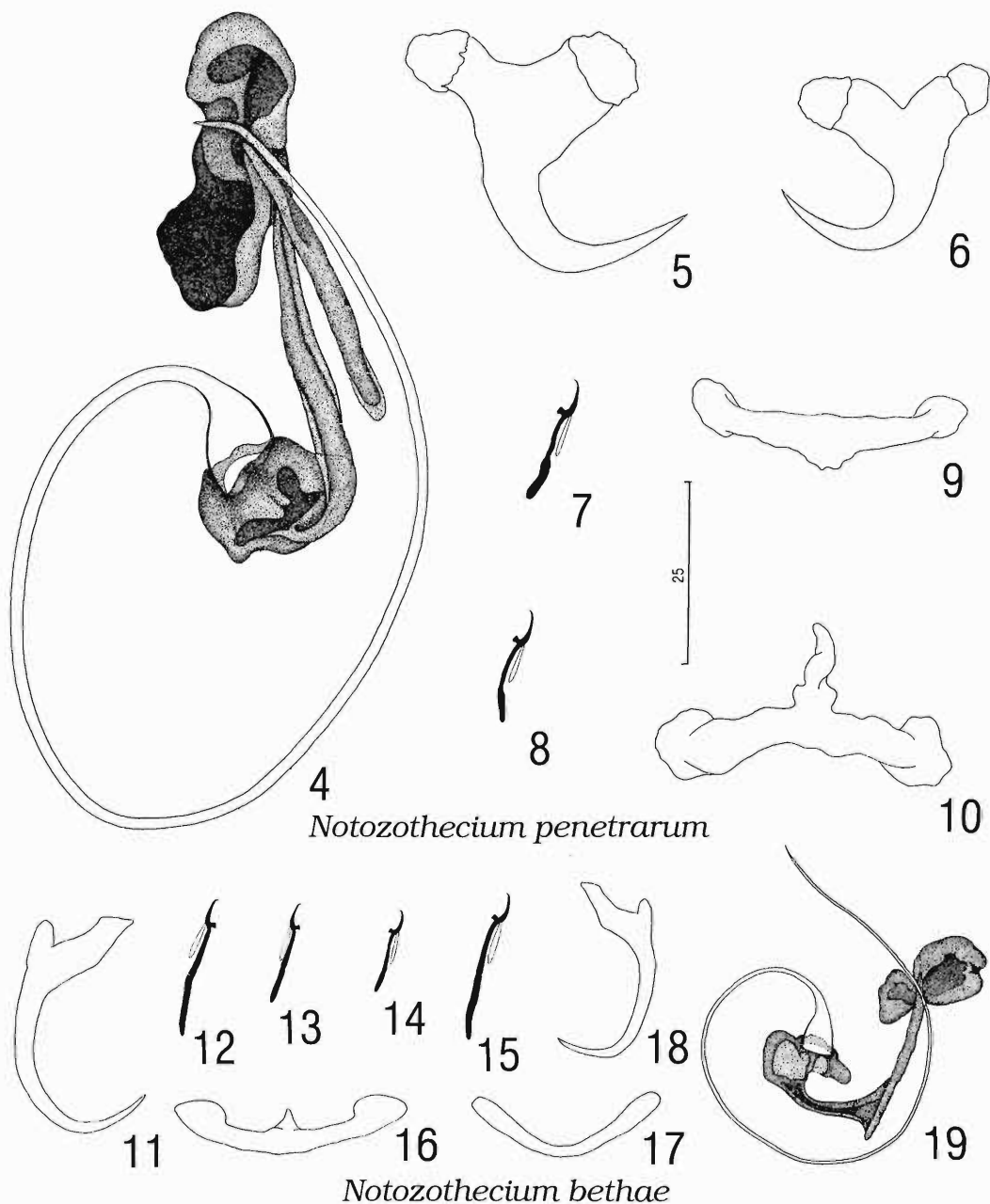
Santos: Rio Tocantins, Cachoeira à montante de Marabá, Pará (all Belmont-Jégu, 1992).

SPECIMENS STUDIED: Holotype, INPA PLH 234; 33 paratypes, INPA PLH 235, USNPC 85729, HWML 38583, from *M. pacu*. Five vouchers from *Myelus rhomboidalis*, USNPC 85730; 5 vouchers from *Mylesinus paraschomburgkii*, collection of E. Belmont-Jégu.

COMPARATIVE MEASUREMENTS: Measurements of specimens from *M. rhomboidalis* (in brackets) follow those of the type series.

DESCRIPTION: Body fusiform, 318 (226–430; $n = 20$) long; greatest width 88 (71–106; $n = 22$)

in posterior trunk. Tegument infrequently with scaled annulations. Cephalic lobes moderately developed. Posterior pair of eyes larger, slightly farther apart than anterior pair; accessory granules usually absent, infrequently few in cephalic, anterior trunk regions. Pharynx spherical, 18 (12–21; $n = 24$) in diameter. Peduncle broad; haptor subhexagonal, 55 (44–81; $n = 23$) long, 69 (61–82; $n = 22$) wide. Anchors similar; each with elongate slightly depressed superficial root, prominent deep root, evenly curved shaft, elongate point; ventral anchor 35 (30–37; $n = 6$) [34 (32–35; $n = 5$)] long, base 14 (13–16; $n = 6$) [14



Figures 4–19. Sclerotized structures of *Notozothecium* spp. 4–10. *Notozothecium penetrarum* Boeger and Kritsky, 1988. 4. Copulatory complex (ventral view). 5. Ventral anchor. 6. Dorsal anchor. 7. Hook pr. 2. 8. Hook pr. 5. 9. Dorsal bar. 10. Ventral bar. 11–19. *Notozothecium bethae* sp. n. (from *Myelus pacu*). 11. Ventral anchor. 12. Hook pr. 7. 13. Hook pr. 1. 14. Hook pr. 5. 15. Hook pr. 4. 16. Ventral bar. 17. Dorsal bar. 18. Dorsal anchor. 19. Copulatory complex (ventral view). All drawings are to the 25- μ m scale.

(13–15; $n = 5$) wide; dorsal anchor 26 (25–27; $n = 6$) [26 (25–27; $n = 5$)] long, base 10–11 ($n = 3$) [9–10 ($n = 5$)] wide. Ventral bar 32 (28–33; $n = 20$) long, yoke-shaped, with enlarged usually

depressed terminations, short triangular anteromedial process. Dorsal bar 25 (21–27; $n = 13$) long, broadly U-shaped, delicate, with slightly enlarged ends. Hook prs. 1, 5–15 (14–16; $n =$

7) [15 (14–16; $n = 7$), pr. 2–21 (19–23; $n = 3$) [20 (19–21; $n = 4$), prs. 3, 4, 7–23 (20–26; $n = 13$) [23 (21–24; $n = 12$)], pr. 6–19 (18–20; $n = 4$) [18 (17–19; $n = 4$)] long. Copulatory organ 116 (93–133; $n = 5$) [93 (88–105; $n = 4$)] long, comprising about $1\frac{1}{4}$ ring; ring diameter 32 (29–35; $n = 4$) [25 (24–26; $n = 4$)]; base with sclerotized margin, small proximal flap. Articulation process of accessory piece uniting with proximal end of distal rod; distal rod 32 (30–34; $n = 6$) [29 (26–31; $n = 5$)] long, straight; flabellate plate nearly perpendicular to distal rod. Testis 44 (38–50; $n = 3$) long, 20–21 ($n = 3$) wide, ovate; vas deferens not observed; seminal vesicle large; dextral prostatic reservoir pyriform; sinistral reservoir subspherical. Germarium 42 (29–54; $n = 11$) long, 18 (15–22; $n = 11$) wide, irregular in outline; oviduct, ootype, uterus not observed; vagina expanded into an inverted cone immediately before entering large kidney-shaped seminal receptacle; vitellaria dense throughout trunk except absent in regions of reproductive organs.

REMARKS: This species was initially reported as an unnamed *Notozothecium* from *Mylesinus paraschomburgkii* and *M. paucisquamatus* by E. Belmont-Jégu (1992) in an unpublished master's thesis. She indicated that it was sister species to *N. minor* based on a phylogenetic analysis of the then 3 known species in the genus. It differs from *N. minor* by possessing a straight distal rod of the accessory piece (submedial double bend in *N. minor*), an elongate proximal articulation process of the accessory piece, a ventral bar with ends slightly directed anteriorly (straight to ends bent slightly posteriorly in *N. minor*), a triangular anteromedial process of the ventral bar, and haptor sclerites smaller and more delicate than those of *N. minor*. It is morphologically similar to *N. euzeti*, from which it differs by having shorter superficial anchor roots. This species is named for Elizabeth Belmont-Jégu, discoverer of the species.

All known hosts of *Notozothecium bethae*, including those recorded by Belmont-Jégu (1992), are rheophilic species and are restricted to the higher fast-flowing reaches of clear- and black-water tributaries of the Amazon. The low host specificity of *N. bethae* suggests that the distribution of this parasite may correlate more with ecological factors associated with fast-flowing streams and their hydrochemical characteristics than with host preferences. However, survey of the monogenoidean parasites of myleine hosts from other habitats within the Amazon Basin

will be necessary to determine the ecological dependencies of this parasite.

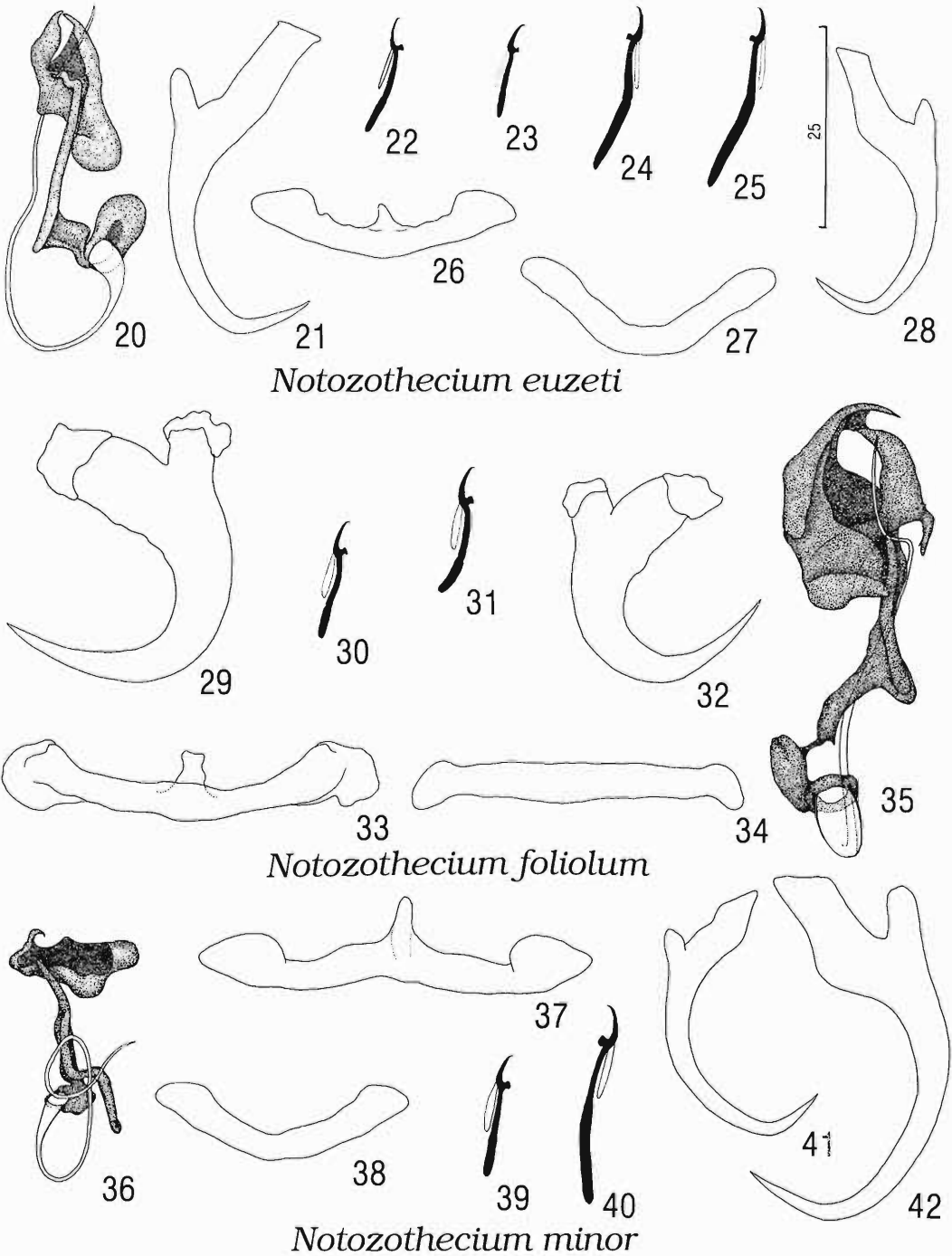
***Notozothecium euzeti* sp. n.**
(Figs. 2, 20–28)

TYPE HOST AND LOCALITY: *Achodon normani*: Kaikuta, Rio Xingu, Pará (10, 14 October 1992).

SPECIMENS STUDIED: Holotype, INPA PLH 220; 19 paratypes, INPA PLH 221, USNPC 85731, HWML 38584.

DESCRIPTION: Body fusiform, 273 (235–329; $n = 10$) long; greatest width 78 (67–116; $n = 10$) usually in anterior trunk. Tegument with scaled annulations throughout trunk, peduncle. Cephalic lobes moderately developed. Posterior eyes larger, slightly farther apart than anterior pair; accessory granules numerous to few in cephalic, anterior trunk regions. Pharynx spherical to subovate, 17 (15–19; $n = 9$) in greatest width. Peduncle broad; haptor subhexagonal, 61 (49–72; $n = 11$) long, 77 (70–85; $n = 10$) wide. Anchors similar, each with long truncate superficial root, prominent deep root, curved shaft, elongate point; ventral anchor 37 (34–40; $n = 8$) long, base 17 (16–19; $n = 7$) wide; dorsal anchor 33 (30–35; $n = 7$) long, base 13 (12–14; $n = 5$) wide. Ventral bar 32 (29–33; $n = 10$) long, arcuate, with enlarged terminations, short triangular anteromedial process. Dorsal bar 31 (28–34; $n = 10$) long, broadly U-shaped. Hook prs. 1, 5–15 (14–16; $n = 7$), prs. 2, 3–22 (20–23; $n = 14$), prs. 4, 7–25 (24–27; $n = 12$), pr. 6–18 (17–19) long. Copulatory organ 72 (68–80; $n = 8$) long, a slender tube of about $1\frac{1}{2}$ rings arising from cone-shaped base, prominent proximal basal flap; ring diameter 21 (17–25; $n = 6$). Articulation process of accessory piece uniting with proximal end of distal rod; distal rod 30 (26–31; $n = 2$) long, usually bent near tip; long axis of flabellate plate nearly parallel to distal rod. Testis 24 (22–25; $n = 2$) long, 16 (14–17; $n = 2$) wide, ovate; prostatic reservoirs subspherical. Germarium 30 (26–34; $n = 5$) long, 14 (13–19; $n = 5$) wide, conical; oviduct, ootype, uterus not observed; vagina delicate, flared into cone before entering kidney-shaped seminal receptacle; vitellaria limited in trunk, absent in regions of reproductive organs.

REMARKS: *Notozothecium euzeti* differs from congeneric species by possessing a ventral anchor with an exaggerated superficial root with truncate tip. It resembles *N. bethae* by lacking a free end of the distal rod of the accessory piece. This species is named for Dr. L. Euzet, Laboratoire de



Figures 20–42. Sclerotized structures of *Notozothecium* spp. 20–28. *Notozothecium euzeti* sp. n. 20. Copulatory complex (ventral view). 21. Ventral anchor. 22. Hook pr. 1. 23. Hook pr. 5. 24. Hook pr. 4. 25. Hook pr. 7. 26. Ventral bar. 27. Dorsal bar. 28. Dorsal anchor. 29–35. *Notozothecium foliolum* sp. n. 29. Ventral anchor. 30. Hook pr. 1. 31. Hook pr. 7. 32. Dorsal anchor. 33. Ventral bar. 34. Dorsal bar. 35. Copulatory complex (ventral view). 36–42. *Notozothecium minor* Boeger and Kritsky, 1988 (from *Serrasalmus spilopleura*). 36. Copulatory complex (ventral view). 37. Ventral bar. 38. Dorsal bar. 39. Hook pr. 1. 40. Hook pr. 7. 41. Dorsal anchor. 42. Ventral anchor. All figures are drawn to the 25- μ m scale.

Parasitologie Comparée, U.S.T.L., Montpellier, France, in recognition of his extraordinary contribution to systematics and taxonomy of the Monogenoidea.

Acnodon normani, the host of this parasite, is a rheophilic species restricted to the upper reaches of the Tocantins and Xingu basins of the eastern Amazon (Géry, 1979; Jégu and dos Santos, 1990). Although the monogenoidean fauna of other species of *Acnodon* are unknown, *Notozothecium euzeti* may be restricted to rheophilic hosts.

***Notozothecium foliolum* sp. n.**
(Figs. 3, 29–35)

TYPE HOST AND LOCALITY: *Pristobrycon* sp.: Rio Negro, Manaus, Amazonas (28 December 1988).

SPECIMENS STUDIED: Holotype, INPA PLH 212; 2 paratypes, USNPC 85732, HWML 38585.

DESCRIPTION: Body foliiform, strongly flattened dorsoventrally, 607 (600–615; $n = 2$) long; greatest width 267 (246–288; $n = 2$) in anterior or posterior trunk. Tegument smooth. Cephalic lobes poorly developed. Posterior eyes larger, slightly farther apart than anterior pair; accessory granules numerous in cephalic, anterior trunk regions. Pharynx spherical, 58 (56–60; $n = 2$) in diameter. Peduncle broad; haptor variable, globose, 101 (88–114; $n = 2$) long, 122 (113–132; $n = 2$) wide. Anchors similar, each with heavy diverging roots with prominent caps, short curved shaft, elongate point; ventral anchor 33 (28–35; $n = 3$) long, base 25 (23–27; $n = 3$) wide; dorsal anchor 27 (26–28; $n = 3$) long, base 19 (17–21; $n = 2$) wide. Ventral bar 48 ($n = 1$) long, straight, with enlarged irregular ends, short truncate anteromedial process. Dorsal bar 42 (41–44; $n = 2$) long, straight, rod-shaped, with slightly enlarged ends. Hook pr. 1–14–15 ($n = 2$), prs. 2, 3, 4, 5, 6, 7–17 (16–18; $n = 8$) long. Copulatory organ 68 (63–78; $n = 3$) long, a slender tube arising from cone-shaped base by sharp bend; ring not apparent; base with sclerotized margin, lacking proximal flap. Articulation process of accessory piece uniting with proximal end of distal rod; distal rod 39 (38–41; $n = 2$) long, straight or somewhat sigmoid; flabellate plate appearing chelate. Testis bacilliform, 124 ($n = 1$) long, 35 ($n = 1$) wide; prostatic reservoirs subspherical to pyriform. Germarium 151 (137–166; $n = 2$) long, 52 (44–59; $n = 2$) wide, forming elongate cone; oviduct, ootype, uterus not observed; vagina with

distal sclerotized funnel; seminal receptacle large, pyriform; vitellaria limited in trunk, absent in regions of reproductive organs.

REMARKS: This comparatively large dactylogyrid shares characters with *N. penetrarum*. Both species have foliiform (dorsoventrally flattened) bodies, modified anchors and ventral bars, and hooks of almost uniform length. They differ in morphology of the copulatory complex. The specific name is from Latin (*foliolum* = a small leaf) and refers to the body shape.

***Notozothecium minor* Boeger and Kritsky, 1988**
(Figs. 36–42)

RECORDS: *Pygocentrus nattereri*: Furo do Catalão, Manaus, Amazonas (6, 27 November 1984). *Serrasalmus elongatus*: Rio Solimões, Ilha da Marchantaria, Manaus, Amazonas (26 November 1984); Rio Negro, Manaus, Amazonas (28 December 1988). *Serrasalmus rhombeus*: Rio Solimões, Ilha da Marchantaria, Manaus, Amazonas (26 November 1984). *Serrasalmus spilopleura*: Rio Uatuma, Lago Tapaná, Santana, Amazonas (3 November 1989); Rio Solimões, Ilha da Marchantaria, Manaus, Amazonas (14 September 1984). *Serrasalmus* sp. (2n = 58): Furo do Catalão, Manaus, Amazonas (30 January 1991).

PREVIOUS RECORDS: *Pygocentrus nattereri* (type host): Furo do Catalão, Manaus, Amazonas (type locality); Rio Mamoré, Surpresa, Rondônia; Rio Guaporé, Surpresa, Rondônia (all Boeger and Kritsky, 1988).

SPECIMENS STUDIED: Three vouchers from *Pygocentrus nattereri*, USNPC 85736; 3 vouchers from *S. elongatus*, USNPC 85738, 85739; 1 voucher from *Serrasalmus rhombeus*, USNPC 85735; 7 vouchers from *S. spilopleura*, USNPC 85733, 85734; 9 vouchers from *Serrasalmus* sp. (2n = 58), USNPC 85737.

COMPARATIVE MEASUREMENTS: See Table 1.

REMARKS: This species was adequately described by Boeger and Kritsky (1988). It has a wide host preference within the Serrasalminae having been found on 5 host species that commonly occur in white, clear, and black waters of the Amazon. *Notozothecium minor* is distinguished from all other congeneric species by having a double bend near the midlength of the distal rod of the accessory piece. It is most similar to *N. teinodendrum*, from which it differs by the latter species possessing a comparatively shorter, straight distal rod of the accessory piece.

Table 1. Comparative measurements (in micrometers) of *Notozothecium minor* Boeger and Kritsky, 1988, from 5 serrasalmid hosts.

	<i>Pygocentrus nattereri</i>	<i>N</i>	<i>Serrasalmus elongatus</i>	<i>N</i>	<i>Serras- almus rhombus</i>	<i>N</i>	<i>Serrasalmus spilopleura</i>	<i>N</i>	<i>Serrasalmus sp. (2n = 58)</i>	<i>N</i>
Body										
Length	—	—	—	—	—	—	251	1	—	—
Width	—	—	—	—	—	—	92	1	—	—
Haptor										
Length	—	—	—	—	—	—	73	1	—	—
Width	—	—	—	—	—	—	73	1	—	—
Pharynx										
Diameter	—	—	—	—	—	—	19	1	20	1
Copulatory organ										
Length	63 (55–75)	3	61 (58–65)	3	58	1	57 (53–60)	3	59 (48–65)	7
Ring diameter	20	2	16	2	15	1	20 (18–21)	2	19 (18–21)	6
Accessory piece										
Length	31 (28–33)	3	33 (31–35)	3	31	1	31 (30–32)	4	33 (30–37)	6
Dorsal anchor										
Length	32 (31–33)	4	31 (30–32)	2	—	—	32 (31–34)	5	32 (31–33)	6
Base width	11 (10–13)	3	11 (10–12)	2	—	—	12 (11–13)	4	11 (10–12)	6
Ventral anchor										
Length	41 (39–43)	6	42 (41–43)	3	41	1	42 (39–45)	6	42 (38–44)	7
Base width	18 (17–19)	6	18 (15–21)	3	17	1	17 (16–18)	5	18 (17–19)	7
Bar length										
Ventral	46 (45–47)	2	41	1	—	—	43	1	42	1
Dorsal	30	1	29	1	—	—	26	1	31	1
Hook lengths										
Pair 1	15	1	17	1	17	1	15	1	17 (16–18)	2
Pair 2	19	1	19	2	19	1	19 (18–20)	2	19 (17–21)	4
Pair 3	23	3	22	1	23	1	23	1	23 (22–24)	3
Pair 4	25	1	25	1	27	1	25–26	3	25–26	3
Pair 5	17	1	17	1	16	1	17–18	4	17 (16–18)	2
Pair 6	20	2	19	1	—	—	21–22	3	21	2
Pair 7	25	1	24	1	—	—	25	1	25	1

***Notozothecium robustum* sp. n.**
(Figs. 43–51)

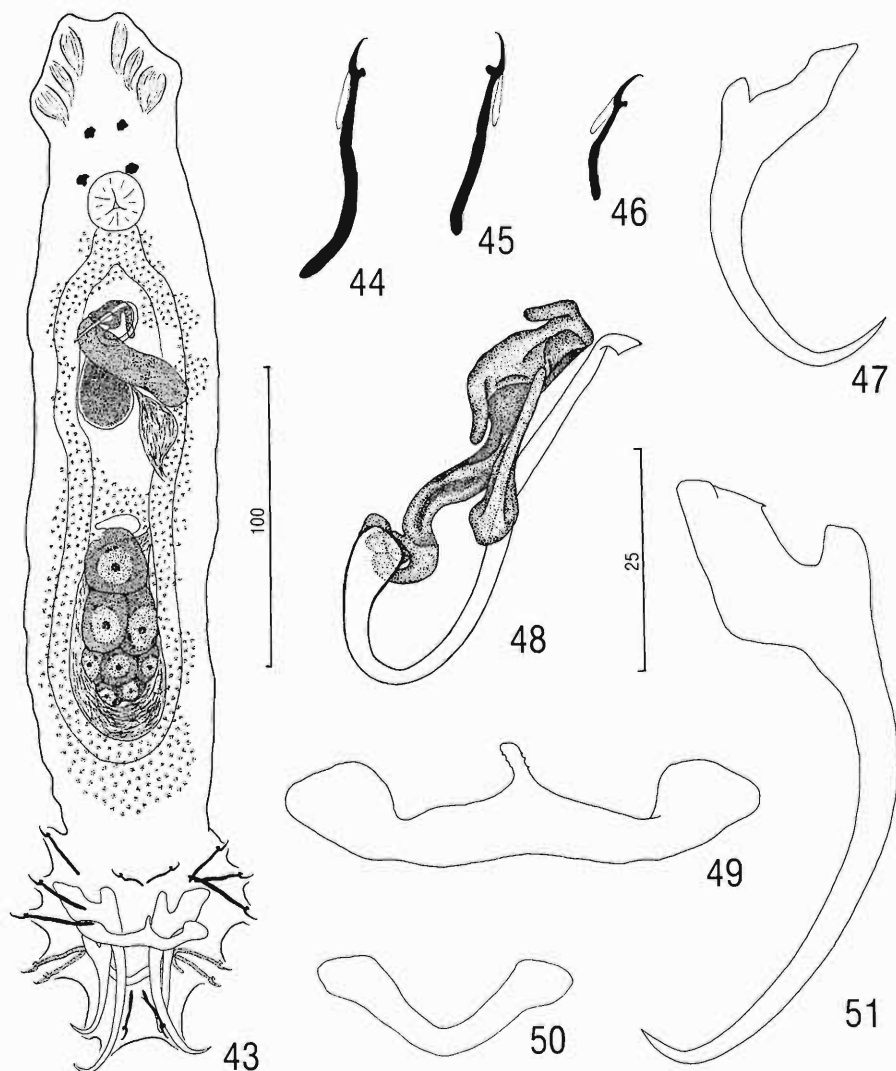
TYPE HOST AND LOCALITY: *Pristobrycon striolatus*; Rio Jatapú, Lago Maracana, Amazonas (2 November 1989).

OTHER RECORDS: *Pristobrycon striolatus*; Rio Capucapú at its confluence with Rio Jatapú, Cachoeira das Garças, Amazonas (31 October 1989); Santa Luzia, Rio Uatumã, Amazonas (20 September 1985); Lago Samaumã, Rio Uatumã, Amazonas (25 September 1985); Rio Xingu, Kaikuta, Pará (12 October 1992).

SPECIMENS STUDIED: Holotype, INPA PLH 222; 33 paratypes, INPA PLH 223, PLH 224,

PLH 225, PLH 226, USNPC 85740, 85741, 85742, 85743, 85744, HWML 38586.

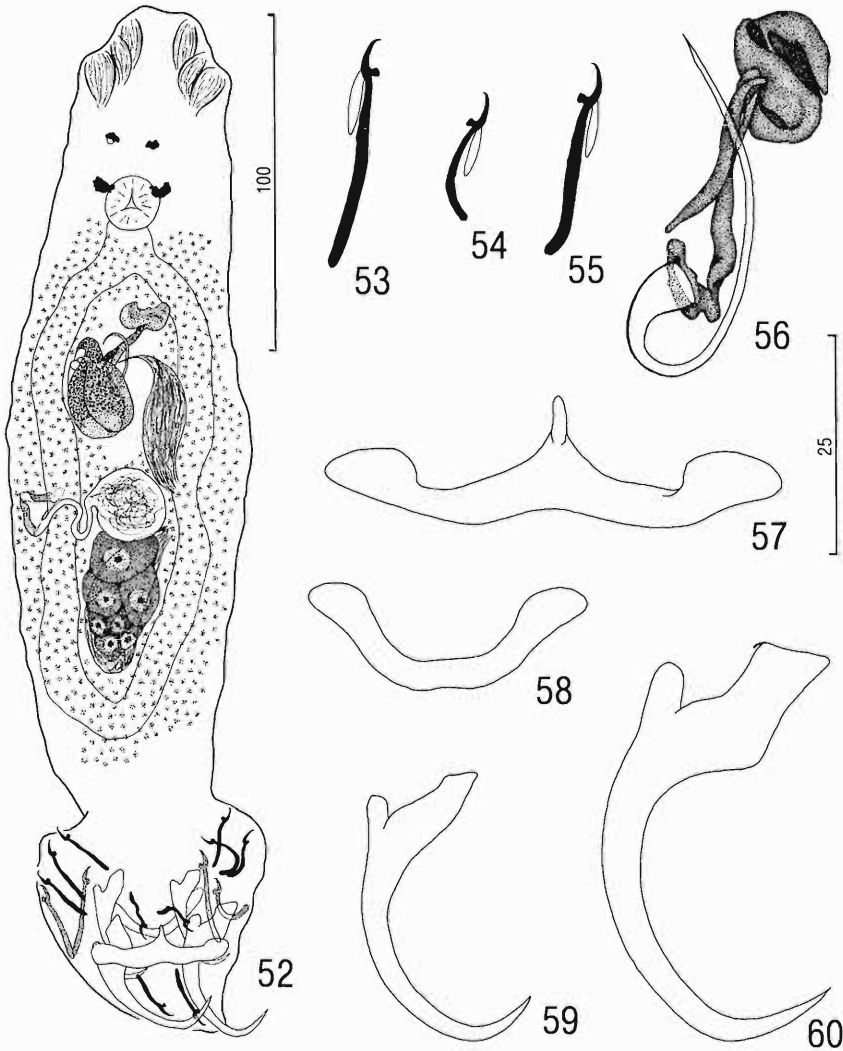
DESCRIPTION: Body fusiform to lateral margins parallel, 328 (227–390; $n = 12$) long; greatest width 81 (66–110; $n = 13$) in anterior or posterior trunk. Tegument smooth, infrequently with scaled annulations. Cephalic lobes moderately developed. Posterior eyes slightly larger, farther apart than anterior pair; accessory granules usually present in cephalic, anterior trunk regions. Pharynx spherical, 18 (13–21; $n = 11$) in diameter. Peduncle broad; haptor subhexagonal, 85 (71–92; $n = 13$) long, 79 (74–85; $n = 12$) wide. Ventral anchor 62 (60–65; $n = 21$) long, with heavy depressed superficial root, prominent deep root,



Figures 43–51. *Notozothecium robustum* sp. n. 43. Whole mount (composite, ventral view). 44. Hook pr. 7. 45. Hook pr. 2. 46. Hook pr. 1. 47. Dorsal anchor. 48. Copulatory complex (ventral view). 49. Ventral bar. 50. Dorsal bar. 51. Ventral anchor. All figures are drawn to the 25- μ m scale except Figure 43 (100- μ m scale).

distinct hump on superficial surface of base, gently curved elongate shaft, short point; base 19 (16–21; $n = 16$) wide. Dorsal anchor 35 (33–36; $n = 18$) long, with elongate slightly depressed superficial root, short deep root, curved shaft, moderately long point; base 15 (13–16; $n = 11$) wide. Ventral bar 45 (43–47; $n = 12$) long, yoke-shaped, with enlarged terminations, short rod-shaped anteromedial process with irregular margins. Dorsal bar 27–28 ($n = 9$) long, broadly U- or V-shaped, with slightly enlarged ends. Hook pr. 1–16 (15–17; $n = 8$), prs. 2, 3, 4–24 (23–26; $n = 24$), pr. 5–17 (16–19; $n = 13$), pr. 6–22 (21–

24; $n = 6$), pr. 7–30 (29–31; $n = 7$) long. Copulatory organ 70 (60–80; $n = 14$) long, comprising robust coil of less than 1 ring, appearing J-shaped; ring diameter 18 (15–20; $n = 10$); base with sclerotized margin, lacking proximal flap. Articulation process of accessory piece elongate; distal rod 31 (27–36; $n = 12$) long, straight, free proximally, with club-shaped proximal end; main axis of flabellate plate perpendicular to converging with distal rod. Testis ovate, 56 (38–69; $n = 5$) long, 34 (26–38; $n = 5$) wide; ventral (sinistral) prostatic reservoir bacilliform, lying diagonally in anterior trunk; dorsal reservoir pyriform. Ger-



Figures 52–60. *Notozothecium teinodendrum* sp. n. (from *Pristobrycon eigenmanni*). 52. Whole mount (composite, ventral view). 53. Hook pr. 7. 54. Hook pr. 1. 55. Hook pr. 4. 56. Copulatory complex (ventral view). 57. Ventral bar. 58. Dorsal bar. 59. Dorsal anchor. 60. Ventral anchor. All figures are to the 25- μ m scale except Figure 52 (100- μ m scale).

marium 56 (47–64; $n = 4$) long, 30 (17–39; $n = 4$) wide, subovate; oviduct, ootype, uterus, vagina not observed; seminal receptacle indistinct; vitellaria limited in trunk, absent in regions of reproductive organs.

REMARKS: We were unable to observe the vagina or vaginal pore in this species. An indistinct duct could be seen in a few specimens originating from the left side of the small seminal receptacle, and we assume a delicate pore occurs on the sinistrodorsal surface of the trunk probably between 2 tegumental annulations. Based on morphology of the haptoral sclerites and cop-

ulatory complex, this species most closely resembles *Notozothecium teinodendrum*. It differs from this and all other congeneric species by possessing a ventral anchor with an elongate shaft and short point. The specific name is from Latin (*robustus* = strong) and refers to the comparatively well-developed copulatory organ.

Notozothecium robustum has been collected from *Pristobrycon striolatus* in only black- and clear-water localities and apparently does not occur in congeneric hosts (*P. eigenmanni*) from white-water habitats in the Amazon Basin. Although the parasite appears restricted to *P. striol-*

Table 2. Comparative measurements (in micrometers) of *Notozotichium teinodendrum* sp. n., from 7 serrasalmid hosts.

	<i>Pristobrycon eigenmanni</i>		<i>Pristobrycon</i> sp.		<i>Serrasalmus elongatus</i>		<i>Serrasalmus gouldingi</i>	<i>Serrasalmus mannielli</i>		<i>Serrasalmus rhombus</i>	<i>Serrasalmus</i> sp. (2 of Jégu)	
	N		N		N		N	N		N	N	N
Body												
Length	250 (198–308)	6	311 (298–324)	2	—	—	358 (298–390)	9	—	—	293 (243–338)	11
Width	73 (65–85)	5	66 (64–69)	2	—	—	91 (72–109)	9	—	—	76 (63–92)	11
Haptor												
Length	68 (62–73)	6	63 (59–67)	2	—	—	78 (68–87)	9	—	—	67 (61–85)	11
Width	72 (56–92)	6	69 (63–74)	2	—	—	92 (86–98)	9	—	—	82 (71–94)	11
Pharynx												
Diameter	14 (12–16)	5	18	2	—	—	21 (19–22)	8	—	—	19 (15–21)	11
Copulatory organ												
Length	70 (63–78)	8	63	2	65	1	64 (60–68)	10	63 (60–65)	2	61 (58–65)	3
Ring diameter	20 (14–21)	7	22 (19–24)	2	17	1	20 (16–23)	9	21 (17–25)	2	20 (16–21)	3
Accessory piece												
Length	31 (28–35)	8	30–31	2	30	1	29 (28–32)	10	25–26	2	28 (27–29)	3
Dorsal anchor												
Length	32 (30–34)	7	30–31	2	32–33	2	32 (30–33)	9	32 (31–33)	2	30–31	2
Base width	13 (11–14)	7	13–14	2	10	1	13 (12–14)	8	13 (11–14)	3	13	1
Ventral anchor												
Length	45 (42–48)	8	41–42	2	45–46	2	45 (42–47)	10	43–44	4	43 (42–44)	3
Base width	19 (18–21)	8	19–20	2	19–20	2	19 (18–20)	10	20–21	4	18–19	3
Bar length												
Ventral	44 (42–46)	6	44–45	2	48	1	45 (42–49)	7	—	—	45 (42–49)	10
Dorsal	30 (28–32)	6	27–28	2	30	1	30 (28–32)	7	—	—	31 (28–35)	10
Hook lengths												
Pair 1	15–16	2	16–17	2	16	1	16–17	2	17	2	—	—
Pair 2	19 (18–20)	5	19	2	19	1	19–20	7	21	1	—	—
Pair 3	21–22	5	21–22	2	—	—	21–22	6	22–23	2	22	2
Pair 4	25 (24–26)	4	25–26	2	26	1	25–26	7	27 (25–28)	3	25–26	4
Pair 5	16–17	2	17–18	2	16–17	2	17–18	9	18	3	17	2
Pair 6	20 (19–21)	6	20	2	19–20	2	20 (19–21)	5	21 (20–22)	2	—	—
Pair 7	26 (23–28)	4	25	2	26	1	26 (25–27)	6	29–30	2	—	—

Table 2. Continued.

	<i>Pristobrycon eigenmanni</i>	<i>Pristobrycon</i> sp.	<i>Serrasalmus elongatus</i>	<i>Serrasalmus gouldingi</i>	<i>Serrasalmus manuellii</i>	<i>Serrasalmus rhombeus</i>	<i>Serrasalmus</i> sp. (2 of Jégu)
	N	N	N	N	N	N	N
Germanium							
Length	30 (28–34)	40 (34–47)	—	—	—	47 (34–52)	—
Width	15 (12–18)	18 (13–24)	—	—	—	18 (12–21)	—
Testis							
Length	28	—	—	—	—	—	—
Width	12	—	—	—	—	—	—

atus, it may also lack a tolerance to the hydrochemical features of white water.

Notozothecium teinodendrum sp. n.
(Figs. 52–60)

TYPE HOST AND LOCALITY: *Pristobrycon eigenmanni*: Nazare, Rio Uatumã, Amazonas (17 September 1985).

OTHER RECORDS: *Pristobrycon eigenmanni*: Rio Jatapú, Lago Maracana, Amazonas (2 November 1989); Rio Negro, Manaus, Amazonas (28 December 1988). *Pristobrycon* sp.: Rio Negro, Manaus, Amazonas (28 December 1988). *Serrasalmus elongatus*: Rio Jatapú, Lago Maracana, Amazonas (2 November 1989). *Serrasalmus gouldingi*: Rio Jatapú, Lago Maracana, Amazonas (2 November 1989). *Serrasalmus manuellii*: Kaikuta, Rio Xingu, Pará (10 October 1992). *Serrasalmus rhombeus*: Rio Jatapú, Lago Maracana, Amazonas (2 November 1989); Rio Uatumã, Amazonas (15 September 1985); Rio Solimões, Ilha da Marchantaria, Manaus, Amazonas (26 November 1984). *Serrasalmus* sp. (2 of Jégu): Nazare, Rio Uatumã, Amazonas (17 September 1985); Rio Jatapú, Lago Maracana, Amazonas (2 November 1989); Rio Uatumã, Lago Tapaná, Santana, Amazonas (3 November 1989); Santa Luzia, Rio Uatumã, Amazonas (20 September 1985).

SPECIMENS STUDIED: Holotype, INPA PLH 214; 13 paratypes, INPA PLH 215, PLH 216, USNPC 85745, 85746, 85747, HWML 38587, from *Pristobrycon eigenmanni*. 5 vouchers from *Pristobrycon* sp., USNPC 85758; 1 voucher from *Serrasalmus elongatus*, USNPC 85754; 19 vouchers from *Serrasalmus gouldingi*, USNPC 85752; 2 vouchers from *Serrasalmus manuellii*, USNPC 85753; 16 vouchers from *Serrasalmus rhombeus*, USNPC 85755, 85756, 85757; 7 vouchers from *Serrasalmus* sp. (2 of Jégu), USNPC 85748, 85749, 85750, 85751.

COMPARATIVE MEASUREMENTS: See Table 2.

DESCRIPTION: Body fusiform; greatest width near midlength. Tegument smooth, infrequently with delicate scaled annulations in trunk, peduncle. Cephalic lobes moderately developed. Posterior eyes larger, slightly farther apart than anterior pair; accessory granules uncommon in cephalic, anterior trunk regions. Pharynx spherical. Peduncle broad; haptor subhexagonal. Ventral anchor with heavy depressed superficial root, prominent deep root, superficial hump on base, curved shaft, elongate point. Dorsal anchor with

well-differentiated roots, curved shaft, moderately elongate point. Ventral bar yoke-shaped, with enlarged terminations, short anteromedial digitiform process. Dorsal bar broadly U-shaped. Copulatory organ a coil appearing J-shaped; base with sclerotized margin, proximal flap absent. Distal rod of accessory piece straight to sigmoid. Testis ovate; prostatic reservoirs pyriform, filled with granules of varying stain affinity. Germarium irregular; oviduct, ootype, uterus not observed; vagina with distal sclerotized funnel; seminal receptacle subspherical, large; vitellaria throughout trunk, absent in regions of reproductive organs.

REMARKS: *Notozothecium teinodendrum* sp. n. appears ubiquitous as a parasite of fishes belonging to *Pristobrycon* and *Serrasalmus*, having been found on 7 host species. It resembles *N. minor*, from which it differs by lacking a submedial double bend of the distal bar of the accessory piece. *Notozothecium teinodendrum* is distinguished from all congeneric species by the relatively large sclerotized distal funnel at the vaginal pore. The specific name is from Greek (*teino* = to stretch + *dendron* = a stick) and refers to the copulatory complex.

Mymarothecium gen. n.

DIAGNOSIS: Body fusiform, comprising cephalic region, trunk, peduncle, haptor. Tegument thin, smooth or with scaled annulations. Two terminal, 2 bilateral cephalic lobes; head organs, unicellular cephalic glands present. Eyes 4; granules ovate. Mouth subterminal, midventral; pharynx muscular, glandular; esophagus short; 2 intestinal ceca confluent posterior to testis, lacking diverticula. Gonads intercecal, overlapping; testis dorsal to germarium. Vas deferens apparently looping left intestinal cecum; seminal vesicle a sigmoid dilation of vas deferens. Two prostatic reservoirs; prostates comprising glandular areas lying dorsal to anterior portions of ceca. Genital pore midventral near level of cecal bifurcation. Copulatory complex comprising articulated copulatory organ, accessory piece; copulatory organ a broad arcuate tube; accessory piece consisting of short proximal articulation process, distal rod, subterminal hooked process originating from distal rod. Vagina nonsclerotized, dilated, opening on middorsal, dextrodorsal, or dextroventral surfaces near midlength of trunk; seminal receptacle absent. Haptor subhexagonal; with dorsal, ventral anchor/bar complexes; 7 pairs

of similar hooks with ancyrocephaline distribution. Ventral bar with anteromedial projection. Hooks similar; each with delicate point, truncate protruding thumb, expanded shank comprising 2 subunits; proximal subunit variable in length between hook pairs; FH loop extending to union of shank subunits. Parasites of gills of serrasalmid fishes.

TYPE SPECIES: *Mymarothecium dactylotum* sp. n. from *Pristobrycon* sp., *S. rhombeus* (type host), *Serrasalmus* sp. (2n = 58), and *Serrasalmus* sp. (2 of Jégu).

OTHER SPECIES: *Mymarothecium galeolum* sp. n. from *Pristobrycon eigenmanni* (type host), *Pristobrycon* sp., *Pygocentrus nattereri*, *Serrasalmus gouldingi*, and *S. rhombeus*; *M. perplanum* sp. n. from *Serrasalmus spilopleura*; *M. whitingtoni* sp. n. from *Serrasalmus rhombeus* and *Serrasalmus* sp. (2n = 58) (type host).

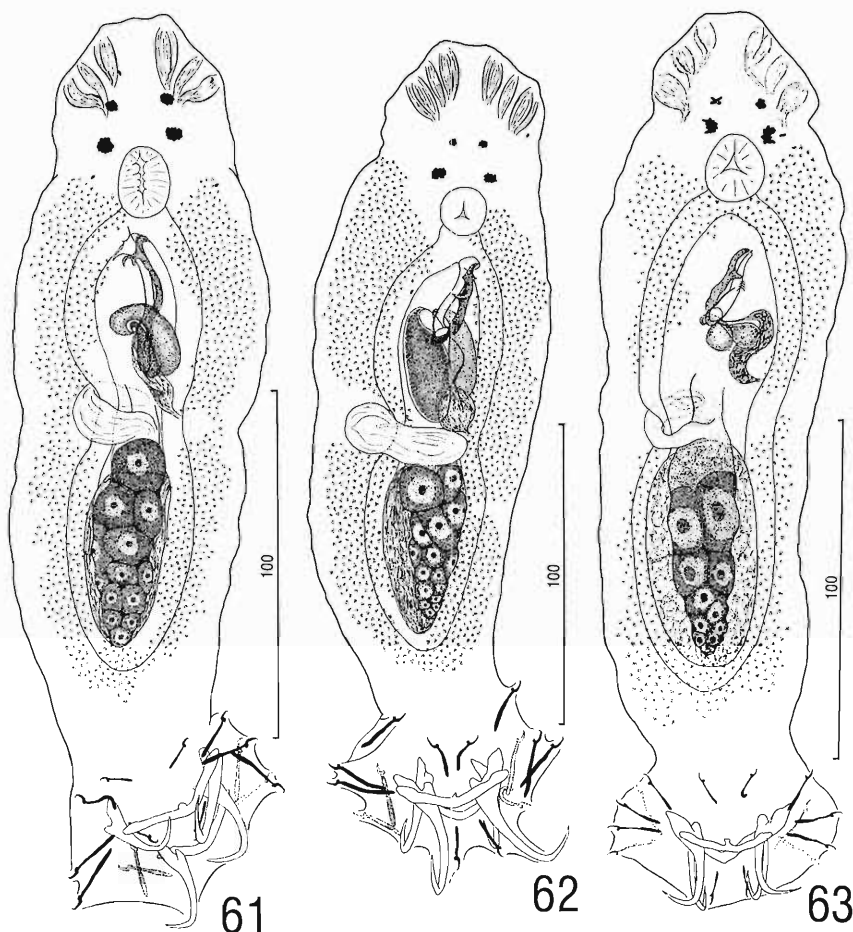
REMARKS: *Mymarothecium* resembles *Notozothecium* by including species with an anteromedial process on the ventral bar and a vagina opening on the right side of the trunk. The genera are distinguished by *Mymarothecium* spp. lacking a coiled copulatory organ and sclerotization of the vagina (present in *Notozothecium*). The generic name is from Greek (*mymar* = a mockery + *theke* = a small case) and refers to the similarity of members of this genus to others infesting serrasalmid hosts, particularly *Notozothecium* species.

Mymarothecium dactylotum sp. n. (Figs. 61, 64–70)

TYPE HOST AND LOCALITY: *Serrasalmus rhombeus*: Rio Pitinga, Igarapé Agua Branca, Rio Uatumã, Amazonas (15 September 1985).

OTHER RECORDS: *Pristobrycon* sp.: Rio Negro, Manaus, Amazonas (28 December 1988). *Serrasalmus rhombeus*: Rio Capucapú at its confluence with Rio Jatapú, Cachoeira das Garças, Amazonas (31 October 1989); Rio Jatapú, Lago Maracana, Amazonas (2 November 1989); Rio Uatumã, Amazonas (15 September 1985). *Serrasalmus* sp. (2 of Jégu): Rio Uatumã, Lago Tapaná, Santana, Amazonas (3 November 1989); Nazaré, Rio Uatumã, Amazonas (17 September 1985). *Serrasalmus* sp. (2n = 58): Furo do Catalão, Manaus, Amazonas (2 November 1993).

SPECIMENS STUDIED: Holotype, INPA PLH 229; 12 paratypes, INPA PLH 230, PLH 231, USNPC 85759, 85760, 85761, HWML 38588 from *Serrasalmus rhombeus*. Two vouchers from



Figures 61–63. Whole-mount illustrations of *Mymarothecium* species (composite, ventral views). 61. *Mymarothecium dactylotum* sp. n. (from *Serrasalmus rhombeus*). 62. *Mymarothecium galeolum* sp. n. (from *Pristobrycon eigenmanni*). 63. *Mymarothecium perplanum* sp. n. Each figure is drawn to the respective 100- μ m scale.

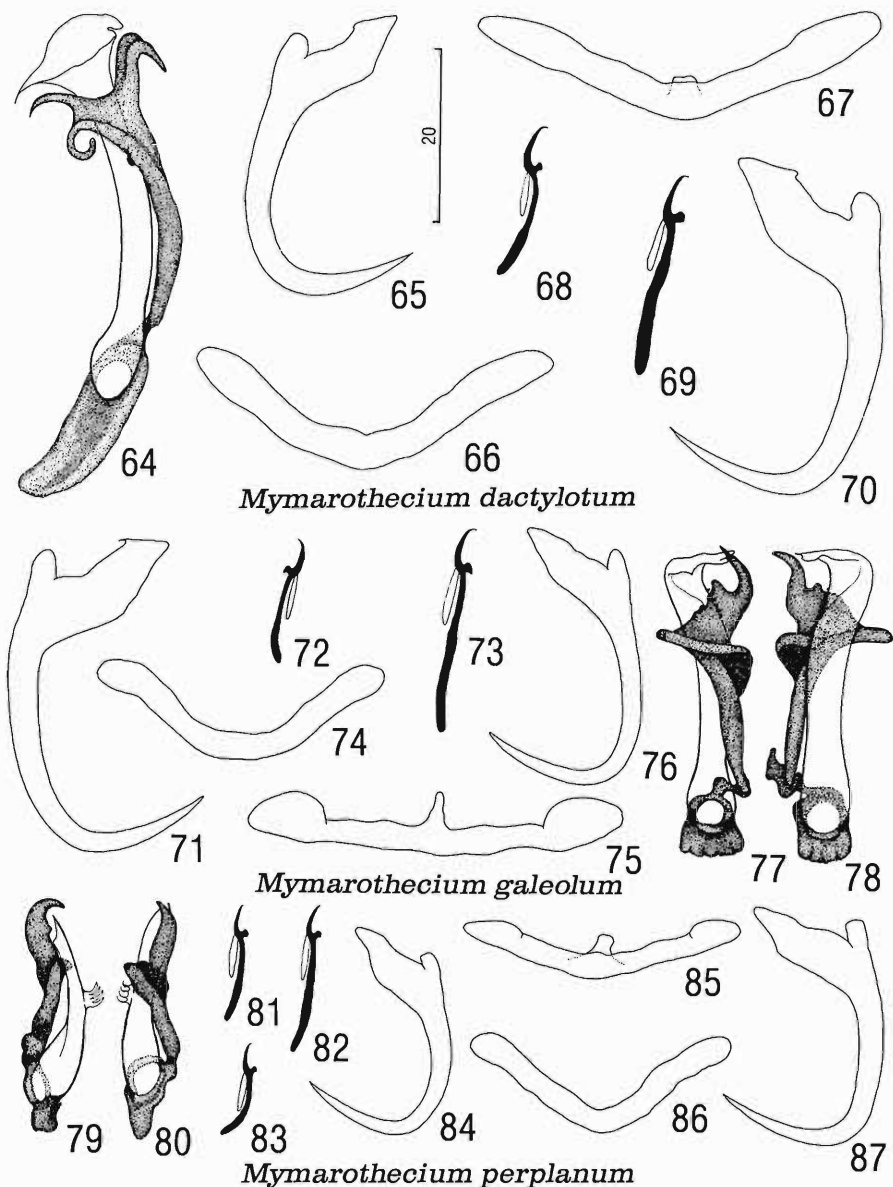
Pristobrycon sp., USNPC 85764; 3 vouchers from *Serrasalmus* sp. (2 of Jégu), USNPC 85762, 85763; 4 vouchers from *Serrasalmus* sp. (2n = 58), USNPC 85765.

COMPARATIVE MEASUREMENTS: See Table 3.

DESCRIPTION: Body tapered posteriorly from midregion of anterior trunk; greatest width in anterior trunk. Tegument smooth or with scaled annulations. Cephalic area broad; cephalic lobes moderately to poorly developed. Posterior eyes larger, slightly farther apart than anterior pair; accessory granules few or absent in cephalic, anterior trunk regions. Pharynx ovate. Peduncle broad. Anchors similar; each with well-developed slightly depressed roots, curved shaft, elongate point. Ventral bar broadly V-shaped or

straight, with short truncate anteromedial process arising from dorsal surface of bar; dorsal bar broadly V- or U-shaped. Copulatory organ a broad tube with distal flare; base with elongate spatulate proximal flap. Distal rod of accessory piece curled distally, subterminal flap with 3 or 4 hook-shaped processes. Testis subovate; prostatic reservoirs elongate; sinistral reservoir looping anterior to base of copulatory organ. Germarium fusiform; oviduct short; ootype, uterus not observed; vaginal aperture middorsal; vitellaria in bilateral fields of trunk.

REMARKS: *Mymarothecium dactylotum* differs from *M. galeolum* and *M. perplanum* by having 3 or 4 distal digits on the subterminal flap of the accessory piece and from *M. whittingtoni*



Figures 64–87. Sclerotized structures of *Mymarothecium* spp. 64–70. *Mymarothecium dactylotum* sp. n. (from *Serrasalmus rhombeus*). 64. Copulatory complex (ventral view). 65. Dorsal anchor. 66. Dorsal bar. 67. Ventral bar. 68. Hook pr. 1. 69. Hook pr. 7. 70. Ventral anchor. 71–78. *Mymarothecium galeolum* sp. n. (from *Pristobrycon eigenmanni*). 71. Ventral anchor. 72. Hook pr. 1. 73. Hook pr. 7. 74. Dorsal bar. 75. Ventral bar. 76. Dorsal anchor. 77. Copulatory complex (ventral view). 78. Copulatory complex (dorsal view). 79–87. *Mymarothecium perplanum* sp. n. 79. Copulatory complex (dorsal view). 80. Copulatory complex (ventral view). 81. Hook pr. 2. 82. Hook pr. 7. 83. Hook pr. 1. 84. Dorsal anchor. 85. Ventral bar. 86. Dorsal bar. 87. Ventral anchor. All drawings are to the 20- μ m scale.

by having the vaginal aperture on the middorsal surface of the trunk (dextroventral in *M. whitingtoni*). The specific name is from Greek (*daktylos* = finger) and refers to the distal end of the accessory piece.

Mymarothecium galeolum sp. n.
(Figs. 62, 71–78)

TYPE HOST AND LOCALITY: *Pristobrycon eigenmanni*: Nazaré, Rio Uatumã, Amazonas (17 September 1985).

Table 3. Comparative measurements (in micrometers) of *Mymarothecium dactylosum* sp. n., from 4 serrasalmid hosts.

	<i>Pristobrycon</i> sp.	<i>N</i>	<i>Serrasalmus</i> <i>rhombeus</i>	<i>N</i>	<i>Serrasalmus</i> sp. (2 of Jégu)	<i>N</i>	<i>Serrasalmus</i> sp. (2n = 58)	<i>N</i>
Body								
Length	—	—	306 (265–411)	6	—	—	—	—
Width	—	—	86 (70–117)	6	—	—	—	—
Haptor								
Length	—	—	59 (55–65)	6	—	—	—	—
Width	—	—	79 (62–93)	6	—	—	—	—
Pharynx								
Diameter	—	—	19 (18–21)	6	—	—	—	—
Copulatory organ								
Length	52	2	48 (43–55)	5	47 (46–49)	2	51–52	2
Accessory piece								
Length	32–33	2	29 (27–33)	5	27 (25–29)	2	29–30	2
Dorsal anchor								
Length	30–31	2	31 (29–35)	6	30 (29–31)	2	31 (29–33)	3
Base width	11–12	2	13 (11–14)	4	12 (11–13)	2	12–13	3
Ventral anchor								
Length	32–33	2	35 (33–37)	6	37 (36–38)	2	34 (33–35)	3
Base width	15 (14–16)	2	15 (13–16)	5	14–15	2	15 (14–17)	3
Bar length								
Ventral	—	—	39 (38–40)	4	—	—	—	—
Dorsal	—	—	34 (32–35)	4	—	—	—	—
Hook lengths								
Pair 1	—	—	15–16	3	16–17	3	17	1
Pair 2	16–17	2	17	2	17	1	17	1
Pair 3	20–21	2	20–21	5	22 (21–23)	3	22–23	3
Pair 4	23 (22–24)	2	24 (23–25)	6	24 (23–26)	3	24–25	3
Pair 5	15	1	15–16	4	15 (14–16)	2	17	1
Pair 6	16–17	2	16–17	5	16–17	3	17	1
Pair 7	20 (19–21)	2	22 (21–23)	5	22 (21–23)	3	23	1
Germarium								
Length	—	—	65 (52–94)	5	—	—	—	—
Width	—	—	22 (18–27)	5	—	—	—	—
Testis								
Length	—	—	62 (50–87)	4	—	—	—	—
Width	—	—	24 (18–34)	4	—	—	—	—

OTHER RECORDS: *Pristobrycon eigenmanni*: Rio Jatapú, Lago Maracana, Amazonas (2 November 1989); Santa Luzia, Rio Uatumã, Amazonas (20 September 1985). *Pristobrycon* sp.: Rio Negro, Manaus, Amazonas (28 December 1988). *Pygocentrus nattereri*: Rio Uatumã, Lago Tapaná, Santana, Amazonas (3 November 1989); Furo do Catalão, Manaus, Amazonas (27 November 1984); Rio Solimões, Ilha da Marchantaria, Manaus, Amazonas (14 April 1984). *Serrasalmus gouldingi*: Rio Jatapú, Lago Maracana, Amazonas (2 November 1989). *Serrasalmus*

rhombeus: Rio Capucapú at its confluence with Rio Jatapú, Cachoeira das Garças, Amazonas (31 October 1989); Rio Jatapú, Lago Maracana, Amazonas (2 November 1989); Rio Pitinga, Igarape Agua Branca, Rio Uatumã, Amazonas (15 September 1985).

SPECIMENS STUDIED: Holotype, INPA PLH 227; 19 paratypes, INPA PLH 228, USNPC 85766, 85767, 85768, HWML 38589 from *Pristobrycon eigenmanni*. One voucher from *Pristobrycon* sp., USNPC 85771; 10 vouchers from *Pygocentrus nattereri*, USNPC 85774, 85775,

Table 4. Comparative measurements (in micrometers) of *Myarothecium galeolum* sp. n., from 5 serrasalmid hosts.

	<i>Pristobrycon eigenmanni</i>	<i>N</i>	<i>Pris- tobry- con</i> sp.	<i>N</i>	<i>Pygocentrus nattereri</i>	<i>N</i>	<i>Serrasalmus gouldingi</i>	<i>N</i>	<i>Serrasalmus rhombeus</i>	<i>N</i>
Body										
Length	295 (221–356)	8	—	—	299 (243–331)	3	363 (267–420)	16	309 (248–427)	11
Width	77 (58–91)	9	—	—	73 (69–76)	3	106 (86–129)	16	95 (74–125)	11
Haptor										
Length	64 (58–76)	8	—	—	60 (59–62)	2	70 (59–78)	16	63 (48–82)	11
Width	71 (62–81)	2	—	—	79 (78–80)	2	97 (82–112)	16	86 (74–111)	11
Pharynx										
Diameter	15 (13–17)	9	—	—	16	3	22 (19–25)	16	20 (17–24)	11
Copulatory organ										
Length	37 (34–40)	10	41	1	38 (33–41)	6	44 (42–46)	3	38 (33–43)	6
Accessory piece										
Length	28 (27–30)	8	33	1	29 (25–33)	6	35 (34–36)	3	31 (26–38)	6
Dorsal anchor										
Length	31 (29–34)	9	29	1	28 (26–31)	6	29–30	3	30 (29–31)	4
Base width	11–12	9	10	1	11 (10–12)	5	11–12	2	13 (12–14)	3
Ventral anchor										
Length	37 (36–41)	7	35	1	34 (33–36)	6	35 (34–36)	3	36 (35–38)	5
Base width	15 (14–16)	8	14	1	15 (13–16)	6	14 (13–15)	3	14 (13–15)	5
Bar length										
Ventral	37–38	5	—	—	38 (36–40)	3	38 (35–40)	14	38 (35–40)	8
Dorsal	30 (29–32)	3	—	—	32 (30–33)	3	32 (30–35)	14	30 (27–33)	6
Hook lengths										
Pair 1	14–15	2	15	1	15 (14–16)	4	16 (15–17)	2	15 (14–16)	2
Pair 2	18 (16–19)	4	17	1	15–16	5	18	1	18 (17–19)	4
Pair 3	21 (20–22)	5	21	1	19 (18–20)	5	21–22	2	21 (20–22)	5
Pair 4	24 (23–25)	6	25	1	21 (20–23)	4	24	1	24–25	4
Pair 5	16 (15–17)	3	—	—	15–16	3	15–16	2	15–16	5
Pair 6	16–17	4	16	1	16 (15–17)	5	—	—	16–17	3
Pair 7	21 (20–24)	7	21	1	19 (18–20)	4	22	1	23	2
Gerarium										
Length	52 (24–77)	8	—	—	57 (43–64)	3	62 (45–73)	15	48 (41–57)	7
Width	18 (12–23)	8	—	—	18 (16–21)	3	23 (19–26)	15	23 (12–30)	7
Testis										
Length	52 (33–64)	8	—	—	58 (43–67)	3	62 (41–94)	14	47 (34–55)	6
Width	19 (11–25)	8	—	—	21 (18–25)	3	28 (21–34)	14	22 (17–27)	6

85776; 19 vouchers from *Serrasalmus gouldingi*, USNPC 85770; 17 vouchers from *Serrasalmus rhombeus*, USNPC 85769, 85772, 85773.

COMPARATIVE MEASUREMENTS: See Table 4.

DESCRIPTION: Greatest width usually in anterior trunk. Tegument with scaled annulations. Cephalic lobes moderately to poorly developed. Posterior eyes larger, farther apart than anterior pair; accessory granules uncommon in cephalic,

anterior trunk regions. Pharynx spherical. Peduncle broad; haptor subhexagonal. Anchors similar; each with well-differentiated slightly depressed superficial root, short deep root, gently curved shaft, elongate point. Ventral bar straight, with short triangular anteromedial projection, enlarged terminations; dorsal bar broadly U-shaped. Copulatory organ a broad straight tube with terminal hood, several small tooth-like pus-

tules on sinistral surface near tip; base with short proximal flap. Distal rod of accessory piece usually with terminal incomplete loop; subterminal flap with hook, thumb. Testis subovate; prostatic reservoirs large, pyriform. Germarium conical; oviduct, ootype, uterus not observed; vagina with slit-like aperture dorsal to right intestinal cecum; vitellaria throughout trunk except absent in regions of reproductive organs.

REMARKS: Features distinguishing this species from its congeners include presence of a terminal broad hook of the subterminal flap of the accessory piece. The specific name is from Latin (*galeola* = a helmet-shaped vessel) and refers to the copulatory organ.

***Mymarothecium perplanum* sp. n.**
(Figs. 63, 79–87)

TYPE HOST AND LOCALITY: *Serrasalmus spilopleura*: Rio Uatumã, Lago Tapaná, Santana, Amazonas (3 November 1989).

OTHER RECORD: *Serrasalmus spilopleura*: Rio Solimões, Ilha da Marchantaria, Manaus, Amazonas (14 September 1984).

SPECIMENS STUDIED: Holotype, INPA PLH 232; 13 paratypes, INPA PLH 233, USNPC 85777, 85778, HWML 38590.

DESCRIPTION: Body 275 (259–289; $n = 5$) long; greatest width 82 (73–91; $n = 5$) in anterior trunk. Tegument smooth or infrequently with scaled annulations. Cephalic area broad; cephalic lobes moderately to poorly developed. Posterior eyes larger, slightly farther apart than anterior pair; accessory granules uncommon in cephalic, anterior trunk regions. Pharynx spherical, 17 (16–18; $n = 5$) in diameter. Peduncle broad; haptor 58 (51–65; $n = 5$) long, 73 (66–81; $n = 4$) wide. Anchors similar; each with well-developed roots, gently curved shaft, elongate point; superficial root slightly depressed; ventral anchor 27 (20–29; $n = 9$) long, base 12 (10–13; $n = 9$) wide; dorsal anchor 25 (24–26; $n = 8$) long, base 9–10 ($n = 6$) wide. Ventral bar 30 (29–31; $n = 3$) long, broadly V-shaped, with short truncate anteromedial process arising from dorsal surface of bar; dorsal bar 25 (23–26; $n = 3$) long, broadly U- or V-shaped. Hook prs. 1, 2, 5, 6–14 (12–15; $n = 23$); prs. 3, 7–17–18 ($n = 16$); pr. 4–20–21 ($n = 6$) long. Copulatory organ a broad flattened tube with dorsal comb arising near midlength; base with short proximal flap; copulatory organ 27 (26–28; $n = 8$) long. Accessory piece 19 (18–20; $n = 6$) long, with comma-shaped subterminal

flap, short distal rod. Testis 47 (40–59; $n = 3$) long, 23 (19–27; $n = 2$) wide, ovate. Germarium with irregular margin, elongate, 49 (38–58; $n = 5$) long, 23 (17–27; $n = 5$) wide; oviduct short; ootype, uterus not observed; vagina opening to right of midline on dorsal body surface; vitellaria in anterior and posterior lateral fields of trunk.

REMARKS: *Mymarothecium perplanum* sp. n. differs from all other congeneric species by possessing a dorsal comb arising near the midlength of the copulatory organ. This species appears restricted to the white waters of the Amazon, the varzea, and lowest portion of the eastern Amazon tributaries, based on the distribution of the host, *Serrasalmus spilopleura*. The specific name is from Latin (*perplanus* = flat) and refers to the flattened tube of the copulatory organ.

***Mymarothecium whittingtoni* sp. n.**
(Figs. 88–95)

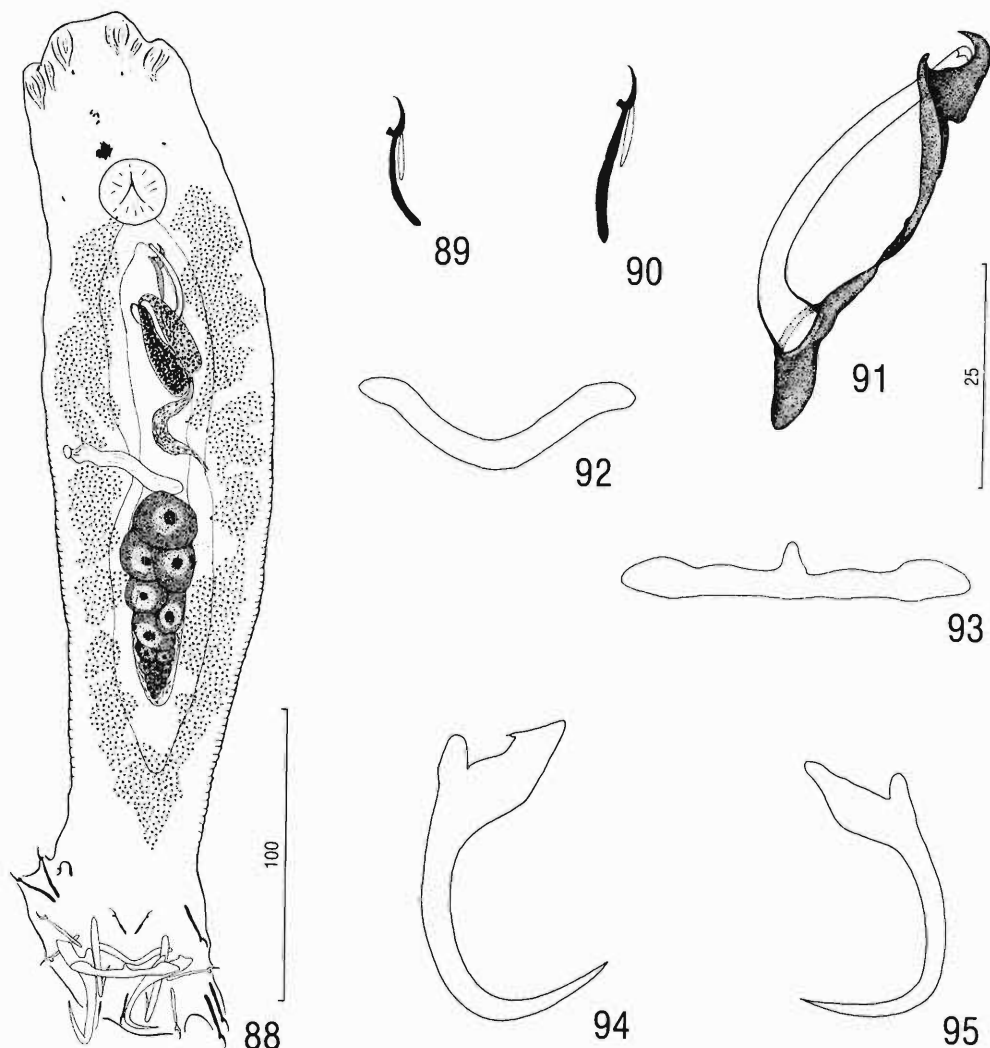
TYPE HOST AND LOCALITY: *Serrasalmus* sp. (2n = 58): Rio Solimões, Ilha da Marchantaria, Manaus, Amazonas (27 October 1993).

OTHER RECORDS: *Serrasalmus rhombeus*: Rio Solimões, Ilha da Marchantaria, Manaus, Amazonas (27, 28 October 1993); Furo do Catalão, Manaus, Amazonas (1, 2 November 1993). *Serrasalmus spilopleura*: Furo do Catalão, Manaus, Amazonas (no date). *Serrasalmus* sp. (2n = 58): Furo do Catalão, Manaus, Amazonas (5 January 1989; 1, 2 November 1993); Ilha do Careiro, Manaus, Amazonas (28 June 1986).

SPECIMENS STUDIED: Holotype, INPA PLH 217; 27 paratypes, INPA PLH 218, PLH 219, USNPC 85779, 85780, 85781, HWML 38591 from *Serrasalmus* sp. (2n = 58). 15 vouchers from *Serrasalmus rhombeus*, USNPC 85782, 85783; 3 vouchers from *Serrasalmus spilopleura*, USNPC 85784.

COMPARATIVE MEASUREMENTS: See Table 5.

DESCRIPTION: Greatest width usually in anterior trunk. Tegument of peduncle, posterior trunk with scaled annulations. Cephalic lobes moderately developed. Eyes usually 4; anterior pair smaller, closer together than posterior pair; anterior members, infrequently 1 member of posterior pair dissociated or absent; accessory granules usually in cephalic, anterior trunk regions. Pharynx spherical. Peduncle broad; haptor subhexagonal. Anchors similar, each with well-differentiated slightly depressed superficial root, short deep root, gently curved shaft, elongate point. Ventral bar straight, with short sub-



Figures 88-95. *Mymarothecium whittingtoni* sp. n. (from *Serrasalmus* sp. [$2n = 58$]). 88. Whole mount (composite, ventral view). 89. Hook pr. 1. 90. Hook pr. 4. 91. Copulatory complex (ventral view). 92. Dorsal bar. 93. Ventral bar. 94. Ventral anchor. 95. Dorsal anchor. All figures are to the 25- μ m scale except Figure 88 (100- μ m scale).

triangular anteromedial projection, enlarged terminations; dorsal bar broadly U-shaped. Copulatory organ arcuate, with anterior and posterior basal flaps. Distal rod of accessory piece somewhat sigmoid; subterminal flap hooked. Testis fusiform to subovate; prostatic reservoirs elongate, pyriform. Germarium conical; oviduct, ootype, uterus not observed; vagina dilated, with slit-like aperture on dextroventral body surface near midlength; 2 bilateral bands of vitellaria confluent posterior to gonads.

REMARKS: *Mymarothecium whittingtoni* dif-

fers from its congeners by having a dextroventral vaginal aperture. This character is apparently derived within the genus and represents an autapomorphy for *M. whittingtoni*. Undoubtedly, more species of this genus have yet to be discovered. Future discoveries may justify erection of a new genus for *M. whittingtoni* based in part on the presence of a dextroventral vaginal aperture. The specific name is in honor of Dr. Ian Whittington, Department of Parasitology, University of Queensland, Australia, in recognition of his valuable work on the Monogenoidea.

Table 5. Comparative measurements (in micrometers) of *Mymarothecium whittingtoni* sp. n., from 3 serrasalmid hosts.

	<i>Serrasalmus rhombeus</i>	<i>N</i>	<i>Serrasalmus spilopleura</i>	<i>N</i>	<i>Serrasalmus</i> sp. (2n = 58)	<i>N</i>
Body						
Length	—	—	—	—	360 (312–435)	7
Width	—	—	—	—	96 (80–118)	8
Haptor						
Length	—	—	—	—	74 (61–85)	7
Width	—	—	—	—	76 (66–89)	7
Pharynx						
Diameter	—	—	—	—	21 (20–23)	8
Copulatory organ						
Length	43 (40–49)	9	45 (43–46)	2	47 (44–50)	13
Accessory piece						
Length	17 (16–19)	12	16–17	3	17 (16–19)	18
Dorsal anchor						
Length	27 (26–29)	11	29 (27–31)	5	28 (26–30)	14
Base width	11 (10–12)	8	11–12	3	11 (10–12)	7
Ventral anchor						
Length	31 (29–33)	13	33 (30–35)	5	32 (30–34)	18
Base width	14 (11–16)	13	15–16	5	14 (13–16)	18
Bar length						
Ventral	—	—	—	—	37 (34–39)	6
Dorsal	—	—	—	—	31 (29–33)	5
Hook lengths						
Pair 1	15–16	5	15–16	3	15–16	10
Pair 2	18 (16–19)	7	18 (17–19)	3	18 (16–20)	11
Pair 3	22–23	6	22–23	3	22 (21–24)	11
Pair 4	24 (23–27)	8	24–25	3	24 (23–26)	10
Pair 5	15–16	8	16	2	15–16	8
Pair 6	18 (16–19)	3	17–18	2	18 (17–19)	8
Pair 7	20–21	5	20–21	5	21 (20–22)	7
Germarium						
Length	—	—	—	—	78 (47–91)	8
Width	—	—	—	—	26 (20–34)	8
Testis						
Length	—	—	—	—	70 (54–86)	6
Width	—	—	—	—	29 (22–40)	6

Discussion

Mymarothecium and *Notozothecium* are apparently sister taxa, but patterns of association of species of these genera with their hosts differ. Species of *Notozothecium* occur on members of 6 host genera (*Myelus*, *Acnodon*, *Mylesinus*, *Pygocentrus*, *Pristobrycon*, and *Serrasalmus*) representing 2 serrasalmid subfamilies (Myleinae and Serrasalminae), whereas *Mymarothecium* species are restricted to serrasalmine hosts (*Pygocentrus*, *Pristobrycon*, and *Serrasalmus*) that ap-

parently originated late in the phylogeny of the subfamily (Machado-Allison, 1983; Ortí et al., in press). These distributions suggest that host-parasite associations in *Notozothecium* and *Mymarothecium* are relatively old, with the common ancestor of the genera occurring on an early serrasalmid form.

In a phylogenetic hypothesis for the Serrasalminae, grounded on morphological data (Machado-Allison, 1983), 2 primary clades, each representing a subfamily, are present. Based on this hypothesis and on host preferences of *No-*

tozothecium spp., the ancestral host for this genus was probably that of the host family. Because species of *Mymarothecium* are known only from members of Serrasalmiinae with comparatively recent origins, extinction of *Mymarothecium* spp. on host clades originating early in the evolutionary history of the Serrasalmidae was apparently not uncommon.

In a competing hypothesis based on chromosome number and nucleolar organizer regions (Porto et al., 1991) and molecular data (Ortí et al., in press) in which the myleine clade (including *Myelus* and *Mylesinus*, but excluding *Colossoma*, *Piaractus*, *Mylossoma*, and *Acnodon*) is sister group to the Serrasalmiinae, the common ancestor of *Notozothecium* and *Mymarothecium* could have occurred on a later serrasalmid ancestor. This idea is tentative because ancyrocephalines are unknown from the gills of species of *Colossoma*, *Piaractus*, and *Mylossoma* spp., 3 genera excluded from the Myleinae in this phylogenetic hypothesis for the Serrasalmidae.

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Announcement

“Diagnostic Parasitology Course” being offered August 5–August 16, 1996, at the Uniformed Services University of the Health Sciences, Bethesda, MD 20814-4799. This course will consist of a series of lectures and hands-on laboratory sessions covering the diagnosis of parasitic infections of humans. In addition to the examination of specimens, participants will be able to practice various methods used in the diagnosis of intestinal, blood, and tissue parasitic diseases. Parasitic diseases encountered throughout the world will be included. Slide presentations and video tapes will be available for study. The course will be held on the University’s campus, utilizing up-to-date lecture rooms and laboratory facilities. Microscopes will be available on a loan basis and laboratory supplies will be provided. Certain reference specimens will also be available for personal use.

The registration fee for the two-week course is \$1,000. U.S. Government and Military personnel may take the course at a reduced rate. Those interested should register as soon as possible as the number of students will be limited. CME credits will be available for this course. Previous laboratory experience is recommended. For further information contact Dr. John H. Cross (301) 295-3139 or Ms. Ellen Goldman (301) 295-3129. FAX: (301) 295-1971.